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XIV. *An Inquiry into the Quantity and Direction of the proper Motion of Arcturus; with some Remarks on the Diminution of the Obliquity of the Ecliptic: By Thomas Hornsby, M. A. Savilian Professor of Astronomy in the University of Oxford, and F. R. S.*

Read Dec. 24,
1772.

AS an accurate knowledge of the position of the fixed stars is of the greatest importance, being the basis and foundation of astronomy, it is no wonder that the astronomers of different nations have given great attention to this matter. By comparing *antient* with the best *modern observations*, it appears that some of the fixed stars have a *proper motion*, independent of any motion hitherto known in our own system; or that, in other words, the *angular distances of the fixed stars have not always continued the same*, and in some of them the alteration is so very considerable as to be easily perceived in the course of *a few years*, with instruments accurately made, and nicely adjusted. Of all the stars visible in our hemisphere, the *variation in the place of Arcturus is the most remarkable*, and such as cannot possibly be attributed to the uncertainty of observation. It has accordingly been taken notice

tice of by many astronomers : in particular, Dr. *Halley* mentions it in N° 355 of the *Philosophical Transactions* : Mr. *Cassini*, in the *Memoirs of the Academy of Sciences* for 1738, p. 231, has shewn, that there is a variation of *five minutes* in the latitude of that star between his own time and that of Tycho, in an interval of a *century and a half* : and M. le *Monnier*, in the *Memoirs of the Academy of Sciences* for 1767, p. 417, proves, that the *latitude* of Arcturus varies at the rate of *two seconds* every *year* ; and that the *longitude* decreases at the rate of 60'' in a hundred years *. But as an *inquiry* as well into the true *quantity* as into the *direction* of this motion has not hitherto been made public, I propose to give some account of my own observations made expressly with this view in the years 1767 and 1768, with a transit instrument of 44 inches, and a moveable mural quadrant of 33 inches, both constructed by Mr. Bird, and of the conclusions resulting from a comparison between them and some observations made by Mr. Flamsteed in 1690.

It may perhaps be objected, that the differences of right ascension, as determined by Mr. Flamsteed's mural instrument, are not to be depended upon from the very nature of his instrument. Mr. Flamsteed was himself too good an observer not to be aware of this ; and accordingly in the *Prolegomena* to the third volume of the *Historia Cœlestis*, p. 132, he informs us in what manner he determined the error of

* See also the *Memoirs of the Academy of Sciences* for 1769, p. 21. See also *Astronomiæ Fundamenta*, by the Abbé de la Caille ; who, in reducing his observations of Arcturus, supposes the annual motion of declination in that star $\approx 19'',0$. p. 169, and 187.

the plane at different distances from the zenith. By distributing these errors in the best manner I could, I am of opinion, that the error of the plane of his instrument may be supposed to decrease uniformly at the rate of half a second in time for every degree of zenith distance from 28° to 60° , the error being $39''$ at the former, and $23''$ at the latter, by which quantity stars passed the horary wire, in his instrument, before they came to the true meridian. It should seem also that the error continued nearly the same from 60 to 75 degrees, being at the latter only $22''$: but that it decreased irregularly from 75° to 85° , viz. $1''$ in time for each degree from 75° to 80° , and $0'',4$ for each degree from 80° to 85 degrees. The mural arc was fixed upon a stone pier, the southern part of which was found to settle yearly, from whence the error of the line of collimation to the south necessarily became every successive year greater and greater. As Mr. Flamsteed seems not to have had any method of adjusting his instrument by a plumb-line, these errors must have been irregular at different seasons of the same year, and were perhaps never truly determined. But as the observations here referred to were made on the same day, and within the compass of an hour, they are probably not affected with this latter error. We are at present concerned with the difference of two zenith distances, and not with the absolute quantity of those zenith distances. The conclusions may indeed be affected with an error in the divisions; and from the examination which I have been able to make, I am of opinion that the arc of Mr. Flamsteed's instrument was not of the proper quantity; and that, though the observations

generally

generally erred in defect, they in some parts erred in excess.

On the 14th of February, 1690, Mr. Flamsteed observed, that a small star, of the seventh or eighth magnitude, whose place is not determined in the British catalogue, and which star was named by him *Infra Arcturum*, preceded Arcturus three seconds in time, or $3'',3$, when an allowance is made for the error of the plane of the instrument $= 0' 42'',6$, and was $26' 30''$ to the south of Arcturus *. By a mean of eight observations made at Oxford, on and near June the 10th, 1767, with the transit instrument, and with a refracting telescope of eight feet, furnished with a micrometer; the difference of right ascension was $1', 8'',75$ of a degree, the star following Arcturus; and by a mean of three observations, the extremes differing only $3''$, the small star was $23' 55'',0$ to the south of Arcturus.

The right ascension of Arcturus and the small star being nearly the same, the change in declination ought to be so likewise. But, from the observed difference in declination, the right ascension of the two stars must vary unequally, though with a very small difference. Accordingly it appears from computation (in which the annual precession is supposed $= 50'',35$, the obliquity of the ecliptic at the middle of the interval of the time $= 23^\circ 28' 30''$, and the right ascensions and declinations of the two stars taken at a mean between the times of observation) that the variation of Arcturus in right ascension was $3270'',6$, and of the small star $3277'',6$ in

* This is the only observation of that star made by Mr. Flamsteed.

77,287 years. Therefore the right ascension of Arcturus alters less than that of the star; and consequently Arcturus should in 1767 have followed the star by $42'',6$. But the star was observed to follow Arcturus by $1' 8'',75$. The right ascension therefore of Arcturus has increased less than that of the star, or Arcturus has moved westward $1' 51'',35$ in 77,287 years; and has gone southward $2' 35''$ in the same time, supposing the small star not to have moved, which is highly probable.

On the same day the difference of right ascension in time between the star η Bootis and Arcturus was $21' 32''$ of mean solar time, $= 5^{\circ} 24' 02'',2$, when a proper allowance is made for the going of the clock, and for the error of the plane of the instrument; and the difference of declination was $50' 45'',6$, when an allowance is made for refraction. On the 24th, 26th, and 29th of May, and the 9th of June, of the year 1768, I determined the difference in right ascension to be $21' 27''$ of sidereal time by the two former observations, and $21' 26\frac{3}{4}''$ by the two latter, the difference in declination being $49' 48'',7$, by a mean of the observations in May, the extremes differing only four seconds. It appears from computation, that between the times of observation the variation of η Bootis in right ascension was $3371'',7$, and $1417'',3$, in declination; of Arcturus $3311'',7$ in right ascension, and $1347'',9$ in declination: The difference of variation in right ascension is $1' 0''$, and of declination $1' 9'',4$; by the former the difference in right ascension was diminished, and in declination increased by the latter, agreeably to the places of the two stars. The difference in right ascension

therefore in 1768, if neither of the stars had moved, should have been $= 5^{\circ} 23' 02'', 2$, and $51' 55''$ in declination; but they were observed to be $5^{\circ} 21' 43'', 4$, and $49' 48'', 7$. Arcturus therefore by this observation has in 78,257 years gone $1' 18'', 8$ to the west, and $2' 06'', 3$ to the south, supposing η Bootis not to have any proper motion.

On the 5th of April, 1691, the difference in right ascension between η Bootis and Arcturus was $21' 33''$ of mean solar time, $= 5^{\circ} 24' 14'', 0$; and the difference of declination $50' 45'', 6$, as in the preceding example. The difference of variation in right ascension is $59'', 1$, and in declination $1' 8'', 4$. The difference of right ascension therefore at the latter end of May, 1768, should have been $5^{\circ} 23' 14'', 9$, and $51' 54'', 0$ in declination; but, according to observation, they were $5^{\circ} 21' 43'', 4$, and $49' 48'', 7$. Arcturus therefore, according to this observation, has moved $1' 31'', 5$ to the west, and $2' 05'', 3$ to the south in 77,120 years.

On the 4th of May, 1691, the difference of right ascension between η Bootis and Arcturus was $21' 33''$ of mean solar time, $= 5^{\circ} 24' 14'', 3$ when allowance is made for the going of the clock and the error of the plane of the instrument, and the difference of declination on the 3d of May $= 50' 50'', 6$. According to computation, those differences should have been $5^{\circ} 23' 15'', 2$ and $51' 59'', 0$ respectively; but they were observed to be $5^{\circ} 21' 43'', 4$, and $49' 48'', 7$. Arcturus therefore in 77,071 years has moved $1' 31'', 8$ westward, and $2' 10'', 3$ southward. N. B. The zenith-distance of Arcturus,
as

as determined by Mr. Flamsteed, on the 4th of May, is manifestly erroneous.

On the 27th of May, 1692, γ Bootis preceded Arcturus in right ascension by $21' 32'',5$ of mean solar time, $= 5^{\circ} 24' 10'',1$, the difference of declination being $50' 50'',6$. In 75,978 years the difference of right ascension should have been $5^{\circ} 23' 11'',8$ and $51' 58'',0$ in declination; but those differences were observed to be $5^{\circ} 21' 43'',4$ and $49' 48'',7$. Arcturus therefore has moved $1' 28'',4$ westward, and $2' 09'',3$ southward.

On the 27th of May, 1692, Arcturus preceded π Bootis in right ascension by $24' 35'',5$ of mean solar time, $= 6^{\circ} 9' 32'',2$, when an allowance is made for the going of the clock and the error of the plane of the instrument, the difference of declination being $3^{\circ} 2' 28'',9$. On the 24th and 26th of May, and 5th of June, 1768, the difference of right ascension between the same stars observed at Oxford was $24' 44'',58$ of sidereal time, $= 6^{\circ} 11' 9'',1$, the difference of declination being $2^{\circ} 58' 24'',2$. In 1768, the difference of right ascension should have been $2'',7$ greater, $= 6^{\circ} 9' 34'',9$; and the difference of declination $1' 31'',7$ less, $= 3^{\circ} 0' 57'',2$. But they were observed to be $6^{\circ} 11' 9'',1$, and $2^{\circ} 58' 24'',2$. Arcturus therefore in 75,978 years has, by a comparison with this star, moved $1' 34'',2$ westward, and $2' 33'',0$ southward.

Again, the difference of declination between Arcturus and π Bootis was observed to be $3^{\circ} 2' 33'',9$ on the 14th of February, 1690, when the difference of right ascension between these two stars was not observed by Mr. Flamsteed. It appears by compu-

tation, that the difference of variation in declination between the times of observation was $1' 34''.5$, by which quantity the difference of declination was diminished, and should therefore in 1768 have been $3^{\circ} 0' 59''.4$. But it was $2^{\circ} 58' 24''.2$ by actual observation. Arcturus therefore by this observation has moved southward $2' 35''.2$ in 78,255 years.

By the foregoing comparisons Arcturus appears to have moved as in the following table.

	years.	Westwd. ' "	Southwd. ' "
By the small star Feb. 14, 1690, in 77,237		1 51,35	2 35,0
η Bootis Feb. 14, 1690, in 78,257		1 18,8	2 6,3
η Bootis Apr. 5, 1691, in 77,120		1 31,5	2 5,3
η Bootis May 4, 1691, in 77,071		1 31,8	2 10,3
η Bootis May 27, 1692, in 75,978		1 28,4	2 9,3
By π Bootis May 27, 1692, in 75,978		1 34,2	2 33,0
π Bootis Feb. 14, 1690, in 78,257		not obs.	2 35,2

As the quantity of the motion of Arcturus southward in declination, as deduced from a comparison with η Bootis, differs considerably from the quantities given by the small star and π Bootis, which agree very nearly together, I have compared η Bootis with some of the neighbouring stars, as that star, though of the third magnitude only, may have a small motion of its own.

On the 14th of February, 1690, the difference of declination between η and π Bootis was observed by Mr. Flamsteed to be $= 2^{\circ} 14' 47''.8$. By computation, that difference in 1768 should have been $2' 43''.9$ less, $= 2^{\circ} 9' 3''.9$: but it was actually observed

observed to be $2^{\circ} 8' 34'',3$ only. The star η Bootis therefore appears by this comparison to have moved southward $29'',6$ in 78,257 years.

On the 27th of May, 1692, η Bootis was observed by Mr. Flamsteed to be $2^{\circ} 11' 37'',8$ to the north of π Bootis, which quantity should by computation be $2' 39'',1$ less in 1768, or $2^{\circ} 8' 58'',7$. But it was found to be $2^{\circ} 8' 34'',3$. The star η therefore appears to have moved southward $0' 24'',4$ in 75,978 years.

On the 25th of April, 1693, η Bootis was observed to be $40' 20'',8$ to the south of f Bootis, a star of the 6th magnitude; and by myself that difference was observed to be $42' 37'',5$, by taking the mean of two observations on the 24th and 26th of May, 1768, differing only $4'',7$. According to computation, the variation of η Bootis in declination during the interval of the two observations was $1359'',3$, and of f Bootis $1256'',0$; and therefore the difference of variation in declination was $1' 43'',3$, by which the distance of the stars was increased. The difference in declination therefore in 1768, if neither of the stars moved, should have been $0^{\circ} 42' 04'',1$; but it was observed to be $33'',4$ greater, by which quantity therefore η Bootis must have moved southward in 75,052 years.

By reducing all the foregoing deductions to 78 years, Arcturus appears to have moved,

Westw.

Westw. Southw.

By the small Star, Feb. 14, 1690	1	52,380	2	36,43
η Bootis Feb. 14, 1690	1	18,541	2	5,88
η Bootis Apr. 5, 1691	1	32,557	2	6,75
η Bootis May 4, 1691	1	32,906	2	11,87
η Bootis May 27, 1692	1	30,752	2	12,74
By π Bootis May 27, 1692	1	36,707	2	37,07
π Bootis Feb. 14, 1690	not observ.		2	34,69

But the Star η Bootis appears also to have moved Southward.

By π Bootis Feb. 14, 1690	0	29,503
π Bootis May 27, 1692	0	25,049
By f Bootis Apr. 5, 1693	0	34,712

By a mean 0 29,755

As Arcturus appears to have moved southward of η Bootis 2' 9'',31, by taking a mean of the four quantities resulting from the comparisons with that star; and as η Bootis has also moved southward of some of the neighbouring small stars by 29'',755 in the same time, Arcturus upon the whole has moved 2' 39''06 to the south, by the comparisons with η Bootis only; and therefore, by taking a mean of all the results, Arcturus has altered its right ascension less than the neighbouring stars by 1' 33'',97 in 78 years, in which time it has also moved 2' 36'',81 to the south of the same stars.

In order to see how far the motion of right ascension is to be depended upon, which is deduced from the above comparisons, I have selected and computed the following observations, made at Shirburn castle

castle with a transit instrument of $5\frac{1}{4}$ feet, placed exactly in the plane of the meridian, and consequently more to be relied upon than those made with a mural instrument.

By a mean of five observations, made on the 7th, 12th, 23d, 24th, and 31st of May, 1741, O. S. the difference in right ascension between γ Bootis and Arcturus was $5^{\circ} 22' 38''.9$, the extremes differing only $4''.4$ of a degree. The difference in the variation of right ascension to the end of May, 1768, is $20''.5$, by which the ascensional difference is diminished. It should therefore have been $5^{\circ} 22' 18''.4$; but it was observed to be $5^{\circ} 21' 43''.4$. Therefore in 27 years Arcturus has moved westward $35''.0$.

On the 16th and 20th of May, 1744, the difference in right ascension between γ Bootis and Arcturus was $5^{\circ} 22' 30''.0$ by each of the observations, which difference should have been, supposing neither of the stars to have any proper motion, $5^{\circ} 22' 11''.7$ in May, 1768. But it was found to be $28''.3$ less; by so much therefore had Arcturus moved westward in 24 years.

On the 24th of May, and 8th of June, 1746, the difference in right ascension between the same stars was $5^{\circ} 22' 26''.2$, by taking a mean of the two observations; that difference should have been $5^{\circ} 22' 09''.5$ in 1768. But it was observed $= 5^{\circ} 21' 43''.4$. Arcturus therefore in 22 years has moved $26''.1$ to the west.

Lastly; on the 16th of April, and 27th and 28th of May, 1747, the difference in right ascension between γ Bootis and Arcturus, by taking a mean of the three observations, was $5^{\circ} 22' 25''.0$. By computation

putation the variation in the difference of right ascension was $16'',0$, by which the ascensional difference should have been diminished, and $= 5^{\circ} 22' 09'',0$. But by observation it was found $= 5^{\circ} 21' 43'',4$: Arcturus therefore by this last observation appears to have gone $25,6''$ westward.

By the observations therefore at Shirburn Castle Arcturus appears to have gone westward as in the following table; in the last column of which are contained the quantities resulting from the observations of each year, reduced to 78 years.

	'	''	'	''
1741	0	35,0	1	41,11
1744	0	28,3	1	31,97
1746	0	26,1	1	32,59
1747	0	25,6	1	34,90
		Mean	1	35,14

The mean of all the observations, when reduced to an interval of 78 years, is $1' 35'',14$, which differs only $1'',17$ from the mean of the other comparisons.

As then the proper motions of Arcturus westward in right ascension $= 1' 33'',974$, and $2' 36'',81$ in declination southward, seem well established, the real motion of Arcturus is inclined in an angle of $30^{\circ} 56'$ to the west of the meridian or horary circle, and to be in that direction $3' 2'',81$ in 78 years, or at the rate of $2'',343$ in a year. As this direction of its motion is nearly perpendicular to the plane of the ecliptic, the latitude of Arcturus must diminish yearly almost in the same proportion; and its longitude will alter less than that of other stars, though not so considerably as its right ascension.

The

The proper motion of Arcturus then, in right ascension Westward, being $1'',205$, and in declination $2'',005$, its annual precession in right ascension is $41'',108$, and in declination $19'',133$; and the true right ascension of Arcturus, on Jan. 1, 1773, is $211^{\circ} 19' 47'',4$, and declination North $20^{\circ} 22' 23'',3$.

As none of the other principal stars have been found to have a motion so considerable as this, though many of the stars of the first magnitude, as for instance, Sirius, Procyon, α Aquilæ, α Orionis, as also β Aquilæ of inferior magnitude, do really vary their positions (and perhaps all of the first order will hereafter be found to have a proper motion), we may, I think, fairly conclude that Arcturus is the nearest star to our system, visible in this hemisphere. If therefore the annual parallax of the fixed stars can ever be discovered, that is, if the diameter of the annual orbit bear a sensible proportion to the distance of the nearest fixed star, it is most likely to be discovered from the observations of Arcturus. The system of the world, considered in an enlarged sense, and agreeable to the idea we may entertain of an all-powerful benevolent Creator, may be taken to occupy the whole abyss of space, and to consist of an assemblage of bodies, having different magnitudes, and emitting various degrees and modifications of light. The apparent change of situation visible from the planet which we inhabit, and which revolves round one of the great bodies constituting a part of the general system, as a center, may be owing either to the motion of our own system in absolute space, or, if our system should be at rest, to a real motion in

the stars themselves: from whence the angular distances of the stars must vary in proportion to the velocity of those motions, or to the direction of those motions with respect to ourselves. I have reason, at present, to believe that a small motion may be discovered in the star α Ceti, and perhaps in other stars that vary in degrees of brightness, which the diligence of future astronomers will discover, and perhaps in less time than at first sight might seem necessary, when we consider the several improvements which have of late been made in the methods of observing the heavenly bodies.

As the motion of Arcturus in declination (the quantity of which we have thus endeavoured to ascertain) has been often acknowledged, it is matter of wonder that some astronomers, by comparing either the altitude or zenith distance of the Sun's limb with Arcturus, without previously settling the quantity of that star's motion in declination, or at least doing it indirectly, should endeavour to determine whether the obliquity of the ecliptic hath remained constant, or still continues to diminish, as it should seem to have done for many centuries past, from the observations of successive astronomers. Mr. Cassini, and Mr. le Monnier, have both practised this method, and are of opinion, that the obliquity of the ecliptic hath not altered; or, if it hath altered, that the quantity of its alteration is not near so considerable as hath been imagined by some celebrated astronomers. By observing for several days before and after the solstice the altitude or zenith distance of the Sun's limb, and that of a star situated near the same parallel, the differences to be remarked in process of time.

time in the distances of the Sun from that star (the motion of the star in declination being allowed for during that interval of time), will be the quantity by which the Sun will have approached to or have receded from the star. If the star were absolutely a fixed point, and the observations sufficiently numerous, that, by taking a mean, the necessary and unavoidable errors in observation might either be considerably diminished or almost annihilated, the method might be practised to great advantage. But as the star (Arcturus) had a proper motion, and its apparent place was continually varying from the effect of the nutation of the earth's axis; as the limb of the Sun was sometimes approaching to, and sometimes receding from, the star, by a kind of libratory motion from the effect of the nutation; also and as the obliquity of the ecliptic itself was, in all probability, continually diminishing; from a combination and as it were involution of these motions no certain conclusion could be drawn, since, in the space of a few years, the apparent obliquity may be the same, and yet the mean obliquity may have diminished, or perhaps, in the space of a few years, the obliquity may appear to have increased, when it may really have become less. Whereas, by reducing the observations to their mean position, and by assigning to each known cause its proper and allowed effect, a regularity and uniformity must necessarily take place, as far at least as is consistent with the unavoidable errors in observing.

Mr. Cassini, in the Memoirs of the Academy of Sciences for 1767, acquaints us, that, in 1748, the apparent distance of Arcturus from the upper limb

of the Sun, at the time of the solstice, was the same as in 1766.

In 1748. Distance of Arcturus from	}	°	'	"	'''
the solstitial limb of the Sun		3	13	36	40
Altitude of Arcturus		61	41	17	0
Therefore the apparent solstitial	}	64	55	13	40
altitude					
In 1766. Distance of Arcturus from	}	°	'	"	'''
the solstitial limb of the Sun		3	19	32	0
Altitude of Arcturus		61	35	42	0
Therefore the apparent solstitial	}	64	55	14	0
altitude					

The same astronomer has, in the Memoirs for 1759, p. 325, communicated the following conclusions.

		Dist. of the star from ☉'s limb.			Reduction.			Solstitial distance.		
1763.		°	'	"	+	'	"	°	'	"
June	14.	3	7	29	+	11	1	3	18	30
	15.	3	10	16	+	8	13	3	18	29
	25.	3	15	40	+	2	48	3	18	28
July	1.	2	59	1	+	19	22	3	18	23
	2.	2	54	55	+	23	33	3	18	28
	3.	2	50	18	+	28	8	3	18	26
		Mean						3	18	27

Mr. le Monnier, in the Memoirs for 1762, p. 269, has published the following distances of Arcturus from the limb of the Sun, reduced to the solstitial point, with a view to obtain differences in the apparent obliquity of the ecliptic: and, from the observations

vations made with the gnomon of St. Sulpice, and communicated by Mr. le Monnier, in the same volume, it should seem that that astronomer is of opinion, that the obliquity of the ecliptic hath no other variation than what the nutation of the earth's axis will occasion; and that therefore we must either abandon the absolute diminution of the ecliptic, or at least suppose it extremely small, since, in the space of eighteen years, it hath not produced a sensible alteration.

	°	'	"
1738.	3	10	15
1740.	3	11	5
1742.	3	11	48

1763.	3	18	40	with the mural quadrant of 5 feet.
	3	18	35	with the large mural instrument.

As the result of the observations only, and not the observations themselves, are communicated, I have only to observe, that there is a very considerable difference between the conclusions of the two astronomers for the same year 1763, and, at the same time, to declare my suspicion, that if the *apparent* (for such I apprehend them to be) were reduced to the *mean* distances, they would probably afford a confirmation of the diminution of the ecliptic. For the following observations of the Sun's zenith distance, made at Shirburn Castle, near the summer solstices of the years 1743, 1746, 1748, and 1766, and of Arcturus in the years 1743, 1746, and 1766, when reduced to their mean state at the solstice, do not confirm the assertion of Mr. Cassini, but are an evident
and

and absolute proof that the obliquity of the ecliptic has sensibly diminished during an interval of 23, and even of 18 years.

The observations of 1743 were made with a mural quadrant of five French feet, constructed by the late Mr. Sisson : but as the linear divisions were found to be somewhat less accurate than was expected, and as the body of the quadrant was not framed with proper strength and solidity, Mr. Bird was employed in the summer of the year 1745, by the Earl of Macclesfield, (the body of the instrument having been strengthened by screwing a large and broad plate of brass upon the cross-bars), to put a set of points upon the limb between the 90 and 96 arches of linear divisions. By these operations the line of collimation was found to have varied, and to be $= 6''.3$, by which the zenith distances were given too small, by the positive divisions, from the end of 1746 to the end of June 1751, when Mr. Bird bisected the spaces between the points which he had formerly added in 1745. But after the year 1751, the error of the line of collimation was $= 2''.6$, as appears from observations of γ Persei, β and γ Draconis, by which the zenith distances are also given too small ; and in that state the instrument continued to the year 1767, when a new set of wires was put into the telescope, and the line of collimation thereby altered. The error of the line of collimation from 1743 to 1745 cannot directly be ascertained, for want of zenith observations ; but, from some indirect methods, it should seem that the error was as nearly as possible $= 2''$, to be added to the observed zenith distances.

[III]

	Observed zenith distance.			Baro- meter.	Thermo- meter.	Refrac- tion.	Sun's semi- diameter.		Dist. from solstice.			Observations re- duced to solstice.		
	°	'	"			" +	'	"	°	'	"	°	'	"
1743.														
June 7.	Up. L.	28	37	39	29,54	62	30,2	+ 15	48,1	0	43	5,7	28	10 51,6
8.	Lo. L.	29	3	37	29,36	60	30,8	- 15	48		37	22,3	28	10 57,5
9.	Up. L.	28	26	44,2	29,46	59½	30	+ 15	47,9		32	3,3	28	10 58,8
12.	Up. L.	28	13	14,5	29,72	61½	29,9	+ 15	47,6		18	31,6	28	11 0,4
18.	Up. L.	27	57	9	29,81	67	29,4	+ 15	47,3		2	30	28	10 55,7
19.	Lo. L.	28	27	28,5	29,54	67½	29,8	- 15	47,2		1	16,1	28	10 55
21.	Up. L.	27	54	41,8	29,66	66	29,1	+ 15	47,1		0	2,8	28	10 55,2
22.	Lo. L.	28	26	22,2	29,50	63	29,8	- 15	47		0	3,4	28	11 1,6
23.	Up. L.	27	55	10,2	29,59	61	29,5	+ 15	47		0	28,6	28	10 58,1
24.	Lo. L.	28	27	35,5	29,59	58	30,4	- 15	46,9		1	18,8	28	11 0,2
25.	Up. L.	27	57	15,5	29,39	58	29,5	+ 15	46,9		2	33,7	28	10 58,2
27.	Lo. L.	28	32	34	29,57	58	30,5	- 15	46,9		6	17,9	28	10 59,7
Mean												28	10 58,2	
Sun's parallax													- 4,1	
Nutation												28	10 54,1	
													+ 6,7	
Line of collimation												28	11 0,8	
													+ 2	
Mean solstitial zenith distance, 1743,												28	11 2,8	
1746.														
May 31.	Lo. L.	29	57	50,5	29,48	78	30,5	- 15	48,8		31	41,9	28	10 50,3
June 5.	Up. L.	28	48	24,8	29,62½	64 -	30,4	+ 15	48,3		53	50	28	10 53,5
6.	Lo. L.	29	13	36,3	29,62	65	30,8	- 15	48,2		47	26,3	28	10 52,6
7.	Up. L.	28	35	58,9	29,53.	71 +	29,4	+ 15	48,1		41	24,3	28	10 52,1
10.	Lo. L.	28	52	1,8	29,28	67	29,8	- 15	47,8		25	49,8	28	10 54
16.	Up. L.	28	0	14,4	28,69	59½	28,7	+ 15	47,3		5	34,6	28	10 55,8
19.	Lo. L.	28	27	5,1	29,60	58½	30,3	- 15	47,2		0	59,8	28	10 48,4
22.	Up. L.	27	54	45	29,75	63½	29,4	+ 15	47		0	8	28	10 53,4
23.	Lo. L.	28	26	47,4	29,85	64	30,2	- 15	47		0	40,4	28	10 50,2
26.	Up. L.	27	59	23,4	29,63	69	29	+ 15	46,9		4	45,9	28	10 53,4
27.	Lo. L.	28	33	6,6	29,63	74½	29,2	- 15	46,9		6	57,1	28	10 51,8
28.	Up. L.	28	4	11,8	29,50	65½	29,3	+ 15	46,9		9	32,9	28	10 55,1
30.	Lo. L.	28	42	5,9	29,22	63½	30,2	- 15	46,9		15	58,2	28	10 51
July 4.	Up. L.	28	28	16,6	29,67	69	29,6	+ 15	46,9		33	40,1	28	10 53
Mean												28	10 52,5	
Sun's parallax													- 4,1	
Nutation												28	10 48,4	
													+ 9,4	
Error of the line of collimation												28	10 57,8	
													+ 6,3	
Mean solstitial zenith distance, 1746,												28	11 4,1	

	Observed zenith distance	Barometer.	Thermometer.	Refraction.	Sun's semi-diameter.	Dist. from solstice.	Observations reduced to solstice.
1748.	° ' "			" +	' "	° ' "	° ' "
June 15.	Up. L. 28 1 21,1	29,51½	64	29,3	+ 15 47,4	0 6 38,6	28 10 59,2
16.	Lo. L. 28 30 41,3	29,55	60	30,3	— 15 47,4	4 31,9	28 10 52,3
20.	Up. L. 27 54 45,7	29,86½	63½	29,5	+ 15 47,2	0 5,7	28 10 56,7
21.	Lo. L. 28 26 11,3	29,65½	75 +	29,2	— 15 47,1	0 1,3	28 10 52,1
22.	Up. L. 27 55 3,5	29,67	81½	28,2	+ 15 47	0 21,4	28 10 57,3
23.	Lo. L. 28 27 18,7	29,60½	72 —	29,3	— 15 47	1 6,7	28 10 54,3
24.	Up. L. 27 56 59,7	29,55+	65	29	+ 15 46,9	2 16,7	28 10 58,9
29.	Lo. L. 28 40 29,3	29,90	64	30,5	— 13 46,9	14 18,7	28 10 55,2

Mean 28 10 55,8
Sun's parallax — 4,1

Nutation 28 10 51,7
+ 6,1

Error of the line of collimation . . . 28 10 57,8
+ 6,3

Mean solstitial zenith distance, 1748, 28 11 4,1

1760.	° ' "			"	' "	° ' "	° ' "
June 11.	Lo. L. 28 47 12	29,51	62 —	30,4	— 15 47,7	0 20 42,3	28 11 12,4
12.	Up. L. 28 11 38,3	29,38	61 —	29,6	+ 15 47,6	16 47,1	28 11 8,4
17.	Lo. L. 28 29 47,9	29,15½	66	29,4	— 15 47,3	3 20,2	28 11 9,8
21.	Up. L. 27 54 57,4	29,72	68¾	29	+ 15 47,1	0 29	28 11 13,5
22.	Lo. L. 28 26 39,6	29,87½	70¾	29,7	— 15 47	0 11,9	28 11 10,4
23.	Lo. L. 28 27 19,2	29,95½	73½	29,5	— 15 47	0 48,6	28 11 13,1
24.	Up. L. 27 56 45,7	29,80	78¾	28,4	+ 15 46,9	1 50,1	28 11 10,9
25.	Lo. L. 28 29 41,2	29,49	74	29,2	— 15 46,9	3 16,2	28 11 7,3
27.	Up. L. 28 2 18,5	29,40	67	28,9	+ 15 46,9	7 22,6	28 11 11,7
29.	Lo. L. 28 29 30,6	29,28	66	29,7	— 15 46,9	13 7	28 11 6,4

Mean 28 11 10,5
Sun's parallax — 4,1

Nutation 28 11 6,4
+ 7,6

Error of the line of collimation . . . 28 11 14
+ 2,6

Mean solstitial zenith distance, 1766, 28 11 16,6

	Observed zenith dist. of Arcturus.			Refrac- tion.	Aber- ration.	Nuta- tion.	Prece- sion.	Observations reduced.		
	°	'	"	"	"	"	"	°	'	"
1743.										
May 12.	31	6	57,8	34	-1,9	+1,4	+2,1	31	7	33,4
17.	31	6	57,8	34	-0,8	+1,4	+1,8	31	7	34,2
18.	31	6	57,8	34	-0,6	+1,4	+1,8	31	7	34,4
June 5.	31	6	52,3	34	+2,9	+1,2	+0,9	31	7	31,3
9.	31	6	50,3	34	+3,8	+1,2	+0,7	31	7	30
10.	31	6	52	34	+4	+1,2	+0,6	31	7	31,8
16.	31	6	57	34	+5,3	+1,2	+0,3	31	7	37,8
18.	31	6	54,8	34	+5,5	+1,2	+0,1	31	7	35,6
25.	31	6	52	34	+6,7	+1,2	-0,2	31	7	33,7
July 1.	31	6	52	34	+7,8	+1,2	-0,5	31	7	34,5
Mean								31	7	33,6
Error of the line of collimation										+ 2
Mean zenith distance of Arcturus, June 21, 1743,								31	7	35,6
Mean zenith distance of the Sun's center, June 21, 1743,								28	11	2,8
Mean distance of Arcturus from the Sun's center, 1743,								2	56	32,8
1746.										
June 4.	31	7	51,1	34	+2,5	-5,8	+1,1	31	8	22,9
21.	31	7	53,1	34	+6,1	-5,9	0	31	8	27,3
22.	31	7	50,2	34	+6,3	-5,9	0	31	8	24,6
23.	31	7	52,3	34	+6,4	-5,9	-0,1	31	8	27,7
Oct. 9.	31	7	53,6	34	+8,9	-6,4	-5,7	31	8	29,4
Mean								31	8	26,4
Error of the line of collimation										+ 6,3
Mean zenith distance of Arcturus, June 21, 1746,								31	8	32,7
Mean zenith distance of the Sun's center, June 21, 1746,								28	11	4,1
Mean distance of Arcturus from the Sun's center, 1746,								2	57	28,6

	Observed zenith dist. of Arcturus.	Baro- meter.	Thermo- meter.	Refrac- tion.	Aber- ration.	Nuta- tion.	Precef- sion.	Observations reduced.
1766.	° ' "			"	"	"	"	° ' "
May 13.	31 14 20,7	29,46	43	34,9	-1,9	-7,6	+2	31 14 48,1
21.	31 14 23,1	29,81	46	35,1	-0,2	-7,6	+1,7	31 14 52,1
22.	31 14 19,9	29,67	49	34,7	0	-7,6	+1,6	31 14 48,6
June 23.	31 14 20,8	29,90	70	33,1	+6,4	-7,7	-0,1	31 14 52,5
Mean								31 14 50,3
Error of the line of collimation								+ 2,6
Mean zenith distance of Arcturus, June 21, 1766,								31 14 52,9
Mean zenith distance of the Sun's center, June 21, 1766,								28 11 16,6
Mean distance of Arcturus from the Sun's center, 1766,								3 3 36,3

From the foregoing observations, it appears that the mean solstitial zenith distance in summer was as follows.

	°	'	"	Variation in 100 years.
				"
1743.	28	11	2,8	60
1746.	28	11	4,1	62,5
1748.	28	11	4,1	69,4
1766.	28	11	16,6	

And, by comparing the three former with the latter, the variation of the obliquity of the ecliptic in 100 years is as is expressed in the last column of the table.

By comparing the distance of Arcturus from the center of the Sun in 1743, with the same distance as observed in 1766 (an allowance being made for the proper motion of the star during the interval, as also for its variation in declination arising from the precession

cession of the equinoxes), it appears that its distance is $17''{,}3$ less than it would have been, if the distance of the Sun's center from the equator had remained unvaried. By that quantity, therefore, the obliquity of the ecliptic has altered in 23 years; which is at the rate of $75''{,}2$ in 100 years.

By comparing, in like manner, the distance in 1746, the obliquity of the ecliptic has diminished $15''{,}6$ in 20 years, or $78''$ in 100 years.

	° ' "		° ' "
Distance in 1743	2 56 32,8	In 1746. 2 57 28,6	
Motion of the star in decl. Southward	7 20,8		6 23,3
Computed distance in 1766	3 3 53,6		3 3 51,9
Observed distance in 1766	3 3 36,3		3 3 36,3
Variation of obliquity	17,3		15,6

The foregoing deductions prove, I think, beyond all doubt, that the obliquity has become less; but as the interval of time between the two terms of comparison is so short, that the errors committed in observing may bear a sensible proportion to the small quantities just now found, and which, perhaps, are somewhat too large; let us have recourse to Mr. Flamsteed's observations, and compare them with observations made by myself, in the course of the last and present years. For this purpose, I have reduced all the observations of the Sun, made in 1690, from May 26 to June 24, O. S. and also all the observations of Arcturus, made in the same year, to their mean position at the summer solstice of that year. The observations, together with my own made at Oxford, are as follows.

	Observed zen. dist. of the Sun's limbs.			Refraction.	Sun's semi-diameter.		Dist. from solstice.			Observations reduced.		
1690.	o	i	"	"	i	"	o	i	"	o	i	"
May 26.	Lo. L.	29	6	20	31,8	15 46,4	o	50	26,1	28	o	39,3
	Up. L.	28	34	50	31,1	15 46,4						41,4
June 2.	Lo. L.	28	31	35	31,1	15 45,7	o	15	28,3			52,1
	Up. L.	28	o	5	30,4	15 45,7						52,8
3.	Lo. L.	28	28	20	31	15 45,6	o	12	8,6			56,8
	Up. L.	27	56	45	30,3	15 45,6						51,1
4.	Lo. L.	28	25	15	30,9	15 45,5	o	9	10,9			49,5
	Up. L.	27	53	55	30,3					28	o	59,9
6.	Lo. L.	28	20	40	30,8	15 45,5	o	4	30,1	28	o	55,2
	Up. L.	27	49	15	30,2					28	i	0,6
7.	Up. L.	27	47	10	30,1	15 45,4	o	2	46,8	28	o	38,7
	Lo. L.	28	18	40	30,8					28	o	38,6
10.	Lo. L.	28	16	10	30,7	15 45,3	o	o	5,5	28	o	49,9
	Up. L.	27	44	40	30,1					28	o	49,9
12.	Up. L.	27	44	50	30,1	15 45,3	o	o	22	28	o	43,4
	Lo. L.	28	16	45	30,8					28	i	8,5
13.	Lo. L.	28	17	17,5	30,8	15 45,1	o	1	7,4	28	o	55,8
	Up. L.	27	45	50	30,1					28	o	58,8
14.	Up. L.	28	13	30	30,8	15 45,1	o	2	17,6	28	o	58,1
	Lo. L.	27	46	50	30,1					28	o	47,6
16.	Up. L.	27	50	40	30,2	15 45,1	o	3	51,8	28	i	3,5
	Lo. L.	28	22	15	30,9					28	i	9
17.	Up. L.	27	53	5	30,2	15 45	o	8	16,4	28	i	3,8
	Lo. L.	28	24	30	30,9					28	o	59,5
20.	Lo. L.	28	34	15	31,1	15 45	o	17	56,4	28	i	4,7
	Up. L.	28	2	45	30,4					28	i	4
24.	Up. L.	28	21	5	30,8	15 45,1	o	36	30,6	28	o	50,3
Mean											28	o 54,2
Error of the line of collimation												i 30
Sun's parallax											27 59 24,2	
											—	4,1
Nutation											27 59 20,1	
											+	9,5
Mean solstitial zen. dist. of the Sun's center, June 11, 1690, O. S.											27 59 29,6	

	Observed zenith dist. of Arcturus.			Refrac- tion.	Aber- ration.	Nuta- tion.	Precef- sion.	Observations reduced.		
1690.	o	'	"	"	"	"	"	o	'	"
Feb. 14.	30	39	20	33,8	—12,2	—5,1	—2,3	30	39	34,2
Apr. 13.	30	39	20	33,8	—5,5	—5,3	—5,4	30	39	37,6
25.	30	39	10		—3,3	—5,4	—6			29,1
26.	30	39	15		—2,9	—5,4	—6,1			34,4
May 13.			10		+0,4	—5,5	—6,9			31,8
14.			10		+0,6	—5,5	—7			31,9
15.	30	39	10	33,8	+0,8	—5,5	—7			32,1
20.			10		+1,9	—5,5	—7,3			32,9
22.			10		+2,3	—5,5	—7,4			33,2
24.	30	39	5		+2,7	—5,6	—7,5			28,4
June 12.			10	33,8	+6,4	—5,6	—8,5			36,1
13.			10		+6,6	—5,6	—8,6			36,2
16.	30	39	10		+7,1	—5,6	—8,7			36,6
17.			10		+7,2	—5,6	—8,8	30	39	33,4
July 1.	30	39	10	33,8	+9,4	—5,7	—9,5	30	39	30,6
Dec. 13.	30	39	35	33,8	—6,6	—6,5	—18,1	30	39	37,6
14.	30	39	40	33,8	—6,8	—6,5	—18,2	30	39	42,3
Mean, January 1, 1690, O. S.								30	39	34
Precession to June 11, 1690										+8,4
Mean zenith distance of Arcturus, June 11, 1690 . .								30	39	42,4
Mean solstitial zenith distance of the Sun's center, } June 11, 1690 }								27	59	29,6
Mean distance of Arcturus in declination from the Sun's } center, 1690 }								2	40	12,8

	Observed ze- nith distance of the Sun's upper limb.	Baro- meter.	Ther- mome- ter.	Refrac- tion.	Sun's semi- diameter.	Dist. from folstice.	Observations reduced.
1771. June 8.	28 36 47,6	30,08 $\frac{1}{2}$	64 $\frac{1}{3}$ —	30,9	15 48	0 36 0,4	28 17 6,1
14.	28 11 38,1	29,94	63 —	30	15 47,4	10 46,6	8,9
18.	28 3 4,4	29,75	61 +	29,7	15 47,2	2 8,3	13
21.	28 0 55,4	30,08 $\frac{2}{3}$	65 $\frac{1}{3}$	29,7	15 47	0 0,8	11,3
22.	28 1 1,4	30,07	66 +	29,6	15 47	0 7,6	28 17 10,4
24.	28 2 26,1	30,07	62	30	15 46,9	1 35,8	7,2
25.	28 3 46,9	30,05	69	29,5	15 46,9	2 56,8	6,5
26.	28 5 38,1	29,97 $\frac{1}{2}$	68	29,5	15 46,9	4 42,7	11,8
29.	28 13 21,3	29,84	61 —	30,2	15 46,9	12 27,7	28 17 10,7
Mean							28 17 8,7
Sun's parallax							— 4,1
Nutation							28 17 4,6 — 6,8
Error of the line of collimation							28 16 57,8 + 4,8
Mean folstitial zenith distance of the Sun's center, 1771,							28 17 2,6

		Observed zenith distance of the Sun's limbs.			Baro- meter.	Ther- mome- ter.	Refrac- tion.	Sun's semi- diameter.	Dist. from solstice.	Observations reduced.			
		°	'	"			"	'	"	°	'	"	
1772. June 8.	Lo. L.	29	4	31,3	30,18	71	30,7	— 15	48	0	31	59,9	28 17 14,1
9.	Up. L.	28	28	1	30,05 $\frac{1}{4}$	67 $\frac{1}{2}$	30,1	+ 15	47,9	27	5,4		21 17 13,6
11.	Lo. L.	28	51	5,5	30,10 $\frac{1}{2}$	71 $\frac{3}{4}$	30,3	— 15	47,7	18	29,2		18,9
12.	Lo. L.	28	47	15,7	30,22 $\frac{2}{3}$	60 $\frac{2}{3}$	31,2	— 15	47,6	14	48,4		10,9
14.	Up. L.	28	9	34,4	30,15 $\frac{1}{2}$	63	30,1	+ 15	47,4	8	38,4		13,5
	Lo. L.	28	41	11,1			30,8						16,1
15.	Up. L.	28	7	5,4	29,94 $\frac{1}{2}$	72	29,2	+ 15	47,3	6	10,7		11,2
	Lo. L.	28	38	40,8			29,8						28 17 12,6
16.	Up. L.	28	5	0,3	29,82 $\frac{1}{2}$	70 $\frac{3}{4}$	29,1	+ 15	47,3	4	7,6		9,1
	Lo. L.	28	36	38,6			29,8						13,5
18.	Up. L.	28	2	16,4	30,02 $\frac{3}{4}$	71 $\frac{1}{2}$	29,2	+ 15	47,2	1	15,6		17,2
	Lo. L.	28	33	48,1			29,7						15
19.	Up. L.	28	1	26,3	29,97	75 $\frac{1}{3}$	28,8	+ 15	47,1	0	26,8		15,4
	Lo. L.	28	32	55,8			29,5						11,4
20.	Lo. L.	28	32	30,3	29,93	79	29,1	— 15	47,1	0	2,8		28 17 9,5
21.	Lo. L.	28	32	32,8	29,79	72	29,6	— 15	47	0	3,5		11,9
22.	Up. L.	28	1	24,8	30,00 $\frac{1}{4}$	73	29	+ 15	47	0	29,9		28 17 10,9
23.	Up. L.	28	2	14,4	30,01	76 $\frac{1}{4}$	28,8	+ 15	47	1	19,4		28 17 10,8
	Lo. L.	28	33	54,1			29,5						17,2
26.	Up. L.	28	7	20,3	29,96	85 —	28,2	+ 15	46,9	6	18,9		16,5
	Lo. L.	28	38	50,4			28,8						28 17 13,4
Mean											28	17	13,4
Sun's parallax													— 4,1
Nutation											28	17	9,3
													— 8,7
Error of the line of collimation											28	17	0,6
													+ 4,8
Mean solstitial zenith distance of the Sun's center, 1772,											28	17	5,4

	Observed zenith distance of Arcturus.	Barometer.	Thermometer.	Refraction.	Aber-ration.	Nuta-tion.	Preces-sion.	Observations reduced.
1772.	" " "			"	"	"	"	" " "
July 11.	31 21 53,6	29,87	73	32,9	+ 9,4	+ 1,9	- 10,1	31 22 27,7
Aug. 11.	31 21 50,6	29,91	04 -	33,8	+ 12,2	+ 2,1	- 11,7	33
17.	50,6	29,93	75 +	32,8	+ 12,2	+ 2,1	- 12	25,7
19.	54,6	29,76	77 -	32,5	+ 12,3	+ 2,2	- 12,1	29,5
Oct. 10.	31 21 58,1	29,99 ¹ / ₄	61	34,2	+ 7,7	+ 2,6	- 15,1	27,2
Nov. 2.	31 22 5,3	29,32 ¹ / ₄	49 -	34,5	+ 4,4	+ 2,7	- 16	28,9
7.	22 3,5	29,25	49	34,3	+ 3,8	+ 2,7	- 16,3	28
12.	8,3	29,82	38	35,9	+ 2,1	+ 2,7	- 16,5	32,5
20.	31 22 12,3	29,85	46 +	34,1	+ 0,4	+ 2,7	- 16,9	31 22 32,6
21.	10,3	29,50 +	42 -	35,4	+ 0,2	+ 2,7	- 17	31,6
25.	11,3	29,37	40	35,2	- 0,2	+ 2,7	- 17,2	31,8
Dec. 10.	15,3	29,62	39 ¹ / ₂	35,7	- 3,9	+ 2,9	- 18	32
15.	31 22 12,3	29,69	45 ¹ / ₄	35,1	- 5	+ 2,9	- 18,3	31 22 27
Mean zenith distance of Arcturus, January 1, 1772								31 22 29,8
Precession to June 21, 1772								+ 9
Mean zenith distance of Arcturus, June 21, 1772								31 22 38,8
Error of the line of collimation								+ 4,2
True mean zenith distance of Arcturus, June 21, 1772								31 22 43
Mean zenith distance of the Sun's center, June 21, 1772								28 17 5,4
Mean distance of Arcturus in declination from the Sun's center, } June 21, 1772								3 5 37,6
o " "								
Mean distance in June 1690								2 40 12,8
Precession, &c. to June 1772								26 16,4
Computed distance in June 1772								3 6 29,2
Observed distance in June 1772								3 5 37,6
Diminution of obliquity in 82-years								51,6

From

From the foregoing observations it appears that, at the summer solstice of the year 1690, Arcturus was $2^{\circ} 40' 12'',8$ to the South of the Sun's center in declination: the motion of the star, in declination, from that time to the summer solstice of the year 1772, including its proper motion, is $26' 16'',4$. Arcturus, therefore, in 1772, should have been $3^{\circ} 6' 29'',2$ to the South of the Sun's center, if the angle of the ecliptic and equator had not varied: but that distance was found by actual observation to be $51'',6$ less. By so much therefore must the obliquity of the ecliptic have become less in an interval of 82 years; and, consequently, the variation in 100 years will be $62'',92$.

If the observations of Arcturus be reduced to the solstice of 1771, and the zenith distance of the Sun's center, as observed in that year, be made use of in the same manner, the variation of the obliquity in 81 years will be found $= 48'',8$, and in 100 years $= 60''$.

If the quantity of the arc of Mr. Flamsteed's instrument were accurately known, the observations which he made at the winter solstice in 1690 might be compared with later observations, in order to determine both the quantity of the obliquity in 1690, and also the variation since his time. Accordingly, I have endeavoured to determine the error of the arc of the instrument between 28° and 75° of zenith distance, and proceeded in the following manner. I computed several observations of the stars ζ Tauri, η Pleiadum, η and μ Geminorum, and ϕ , σ , and \circ Sagittarii, as observed by Mr. Flamsteed, in the years 1690, 1691, and 1692, and reducing them

to the years 1760 and 1766, I compared the differences of declination between those stars, resulting from Mr. Flamsteed's observations, with the differences given by the places of the same stars, as settled by Dr. Bradley in 1760, and also by actual observations of the same stars made at Shirburn-Castle in 1766; and, by combining these differences together, I found that the whole arc of 90 degrees was too short by $43''$. Supposing the error to be uniform, the proportional part of this quantity, thus found for the solstitial zenith distance of the Sun in June $= 13'',4$, is nearly confirmed upon the authority of Mr. Flamsteed himself, who, in the prolegomena to the third volume of the *Historia Cœlestis*, where he is deducing the latitude of the Royal Observatory at Greenwich, and the quantity of the obliquity in 1690, from his own observations, allows the zenith distances at 28° , 36° , and 40° , on his instrument, to be too small by $15'$ and by $20''$, at 75° .

I have therefore computed the observations of the Sun, made from November 30 to December 20 of 1690, which, reduced to the solstice, are as in the following table; to which are subjoined the observations made by myself at Oxford, at the winter solstice of 1771.

	Observed zenith distance of the Sun's limbs.	Refrac- tion. +	Sun's semi- diameter.	Dist. from solstice. +	Observations reduced.
1690.	° ' "	' "	' "	° ' "	° ' "
Nov. 30.	Lo. L. 74 45 17,5	3 27,9	— 16 16,6	0 25 43,1	74 58 11,9
	Up. L. 74 12 40	3 19,6	+ 16 16,6		74 57 59,3
Dec. 2.	Lo. L. 74 54 5	3 28,7	— 16 16,6	17 16,1	74 58 33,2
	Up. L. 74 21 25	3 21,7			19,4
10.	Lo. L. 75 11 0	3 32,7	— 16 17,2	0 4,6	20,1
	Up. L. 74 38 35	3 25,4			22,2
13.	Lo. L. 75 9 50	3 32,4	— 16 17,2	1 24,4	74 58 29,6
	Up. L. 74 37 15	3 25,3			21,9
15.	Lo. L. 75 6 45	3 31,6	— 16 17,3	4 39,4	74 58 38,7
	Up. L. 74 34 5	3 24,5			26,2
17.	Lo. L. 75 1 30	3 30,2	— 16 17,3	9 46,9	29,8
20.	Up. L. 74 13 15	3 19,8	+ 16 17,3	25 38,8	74 58 30,9
	Lo. L. 74 46 5	3 27	— 16 17,3		74 58 53,5
Mean					74 58 25,9
Error of the line of collimation					— 1 10
Sun's parallax					74 57 15,9
					— 8,5
Nutation					74 57 7,4
					— 9,6
Mean solstitial zenith distance of the Sun's center, Dec. 1690,					74 56 57,8

	Observed zenith distance of ☉'s upp. limb.	Barometer.	Thermometer.	Refraction.	Sun's semi-diameter. +	Dist. from solstice. +	Observations reduced.
1771.	° ' "			' "	' "	° ' "	° ' "
Dec. 8.	74 11 1,7	29,43	44 $\frac{1}{4}$	3 21	16 18	0 42 26,3	75 13 12,2
12.	74 32 25,4	29,56 $\frac{1}{3}$	47 +	3 25,2	16 18,5	21 3,4	17,7
16.	74 46 32,3	28,68	45 $\frac{2}{3}$	3 22,7	16 18,7	7 2,5	21,8
19.	74 51 57,3	29,23	42	3 29,6	16 19	1 26,1	17,2
24.	74 51 48,5	29,07	40	3 29,6	16 19,1	1 31	13,4
25.	74 50 24,2	29,43	41 $\frac{1}{4}$	3 31,2	16 19,2	2 56,9	16,7
27.	74 46 13,3	29,42 $\frac{1}{2}$	48 $\frac{1}{2}$	3 26,6	16 19,2	7 13,4	17,7
30.	74 36 13,9	30,13	39 $\frac{3}{4}$	3 34,1	16 19,3	17 9,3	75 13 21,8
Mean	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	75 13 17,3
Sun's parallax	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	— 8,5
Nutation	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	75 13 8,8 + 7,9
Error of the line of collimation	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	75 13 16,7 + 4,8
Mean solstitial zenith distance of the Sun's center, December 1771,	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	75 13 21,5

The mean obliquity of the ecliptic resulting from the zenith distances, as observed at the two solstices in 1690, by applying the known latitude of the place, will be found to be widely different, if no correction be applied for the error of the instrument.

	° ' "		° ' "
June, zenith distance	— 27 59 29,6	Dec. zen. dist.	74 56 57,8
Latitude of Greenwich	51 28 38		— 51 28 38
	23 29 8,4		23 28 19,8

But if the observations be corrected by the error of the instrument, the two results will be found to agree together as nearly as can be expected.

• ' "	' "
27 59 29,6	74 56 57,8
+ 13,4	+ 35,8
<hr/>	<hr/>
—27 59 43	74 57 33,6
51 28 38	—51 28 38
<hr/>	<hr/>
Obliquity 23 28 55	23 28 55,6

Or, if the obliquity be required independent of a knowledge of the latitude of the place, it will be found to be $\equiv 23^{\circ} 28' 55'',3$.

December	° ' "
June	— 74 57 33,6
	27 59 43

Difference	46 57 50,6
Mean obliquity 1690, $\frac{1}{2}$ Diff.	23 28 55,3

By comparing the observations at the summer solstices of 1771 and 1772 with those at the winter solstice of 1771, it appears that the mean obliquity was about the beginning of the year 1772 $\equiv 23^{\circ} 28' 9'',4$ and $23^{\circ} 28' 8''$. I suppose therefore the mean obliquity to be $23^{\circ} 28' 8''$ at the beginning of the present year; and consequently, the obliquity has diminished, by my observations, $47''$ in 81 years, since Mr. Flamsteed's time, or at the rate of $58''$ in 100 years, a quantity which will be found nearly at a mean of the computations framed by Mr. Euler and Mr. de la Lande, upon the principles of attraction.

Oxford, Dec. 23, 1772.